Scalable Parallel Computing for Photonic Research Simulations

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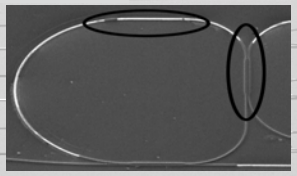
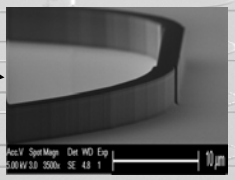
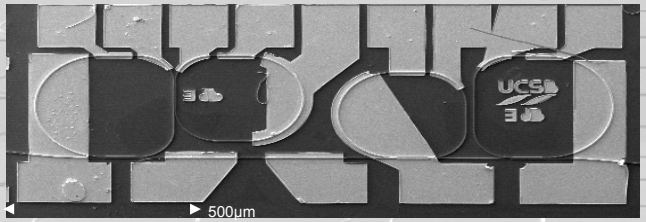
Photonic Integrated Circuits

A Photonic Integrated Circuit (PIC) is a single chip (<1cm^2) with multiple integrated optical components (10-1000 components per chip). PICs can be used extensively for telecommunications hardware including transmitters, receivers, and routers. PICs offer faster speeds, reduced size, and reduced power consumption over discrete lasers and electronic components.





Waveguide (courtesy Coldren group)



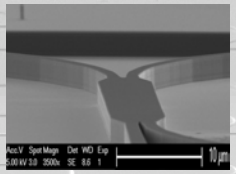
SEM photo of a photonic integrated circuit. (Courtesy of John Parker)

Optical Components:

Waveguides Provides a path for light propagation. Comparable to a wire trace in an electrical circuit.

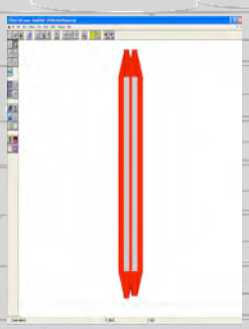
Couplers Provides a junction for two waveguides.

Amplifiers Uses electrical current to increase the light intensity through the circuit.

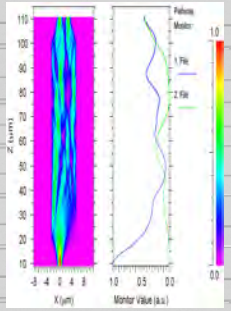


Coupler (courtesy Coldren group)

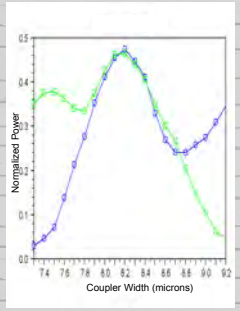
The Problem: Photonic Simulations



CAD drawing of a coupler



Simulation in progress



Simulation Output.

Some deviation from the ideal feature size occurs during the component fabrication. The devices are highly sensitive to the physical shape of every optical component. Therefore, extensive simulations using RSoft BeamProp/Fullwave software are used to optimize the design for minimal loss and maximum fabrication tolerance.

Lengthy simulations must be done with multiple parameter sweeps to ensure that the design is robust against fabrication variations. Until now sweeps have been executed using a single computer to repeat simulations while varying one or two parameters. This is time consuming.

Approach: BatchSim Software

I created software that makes use of multiple computers throughout the lab to simultaneously run separate discrete portions of the simulation to speed up the process. This software had the following requirements:

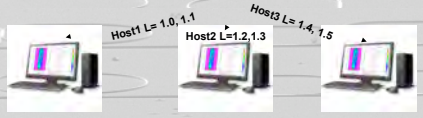
- It must interface with the existing RSoft CAD software.
- It must make use of existing computers in the lab and use the existing network.
- It must run autonomously once the initial sweep data has been entered.
- It must output the data in a form identical to the original RSoft software.

Step 1:Create a CAD drawing of the optical component.

Step 2: Start BatchSim. Input sweep information.

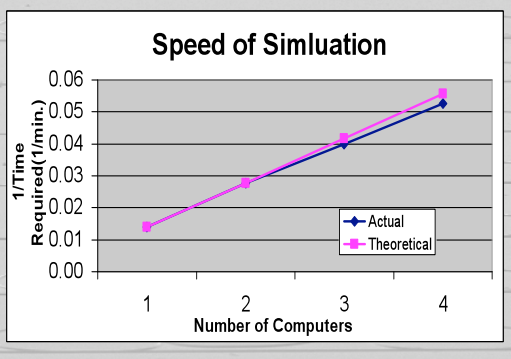
Step3: BatchSim automatically divides simulations across network computers and calls computers to begin simulations.

Step 4:Host computers work independently. Each computer calls master computer when done.

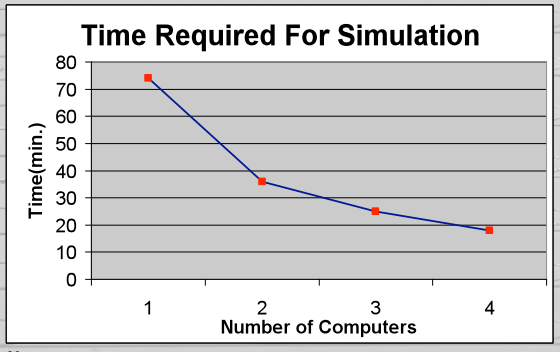


Step 5: When hosts have finished simulation the master collates the data and puts it in graph form.

Results



Because these simulations run independently on each network computer, there is a near-linear increase in speed as more and more computers are used. There are some redundant, overhead processes which each computer must run. This reduces the actual performance slightly from the theoretical speed.



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